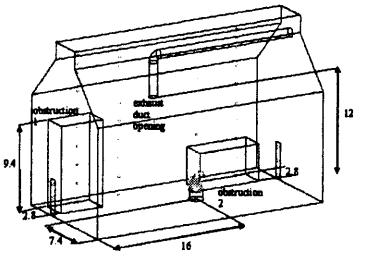
WPI

The University of Science and Technology. And Life.™

Misusing (Using) Fire Models



Jonathan Barnett
Center For Firesafety Studies
Worcester, MA 01609

The Setting

- FP571 performance based design.
- Nine students divided into three groups.
- Students are typically 2nd semester post graduate students with undergraduate degrees in mechanical or civil engineering.

WPI The University of Science and Technology. And Life.™

Student Subject Background

- Fire dynamics (Drysdale's text).
- Building analysis (primarily code analysis with an introduction to performance issues).
- Fire suppression systems.

Work Experience

- Typically one year working for a fire protection consultancy. Some students had no experience, one had over five dealing with shipboard firesafety

Computer Experience

- Minimal exposure typical for an engineering undergraduate
- Limited exposure to the use and concept behind zone models
- Some students had knowledge of CAD, all had basic windows skills

Assignment

- Complete part I of benchmark exercise # 2 *"fire in a large hall."*
- Duration: 4 weeks (final week for report writing)
- Tools:
  - Jasmine
  - FDS
  - CFAST

Common Issues - CFD

- Tedium in setting up geometry

Common Issues - CFD

- Grid
  - Difficulty in matching mesh to the sloped ceiling, often resulted in very fine grid just to match geometry, not needed from a modeling perspective
  - Minor but annoying: modeling circular fire with square/rectangular grid, matching grid points with thermocouple locations.

Common Issues - CFD

- Long computation times, especially with JASMINE
- Lack of time to evaluate sensitivity to grid – makes results questionable
- Interpretation of results – as there was no hot layer, how do you report a hot layer temperature? Even when there is a hot layer, how do you determine its location?

Issues With CFAST

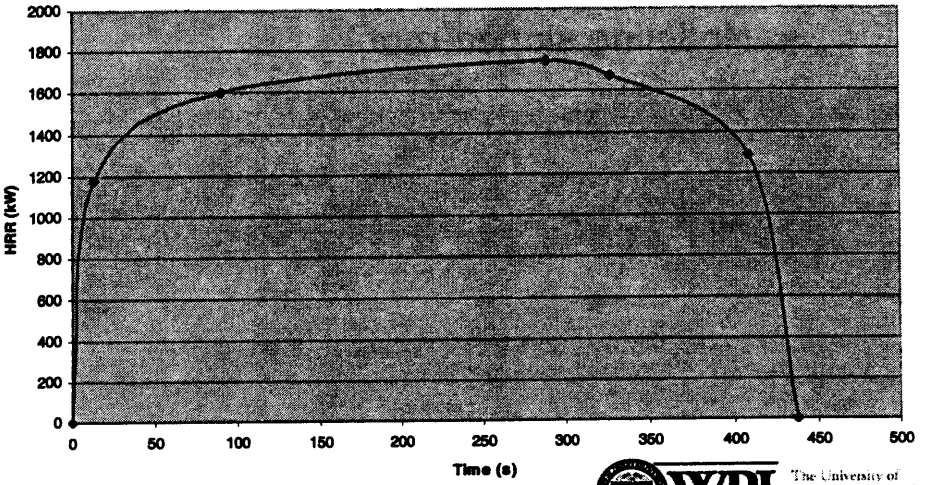
- Modeling sloped roof

Jasmine – The Fire

- Equivalent area.
- Default values for Heptane.
- Modified Ultra-fast t-squared fire, then
- Steady state, finally
- Jasmine default for decay phase.

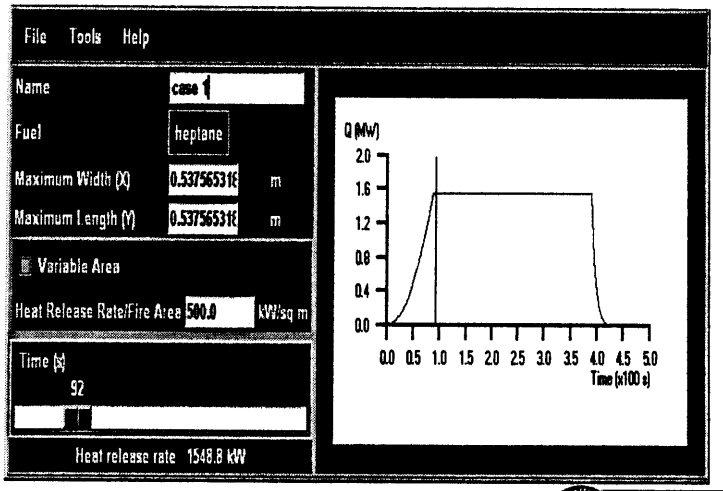
WPI The University of Science and Technology And Life.™

Case 1 – HRR v. Time

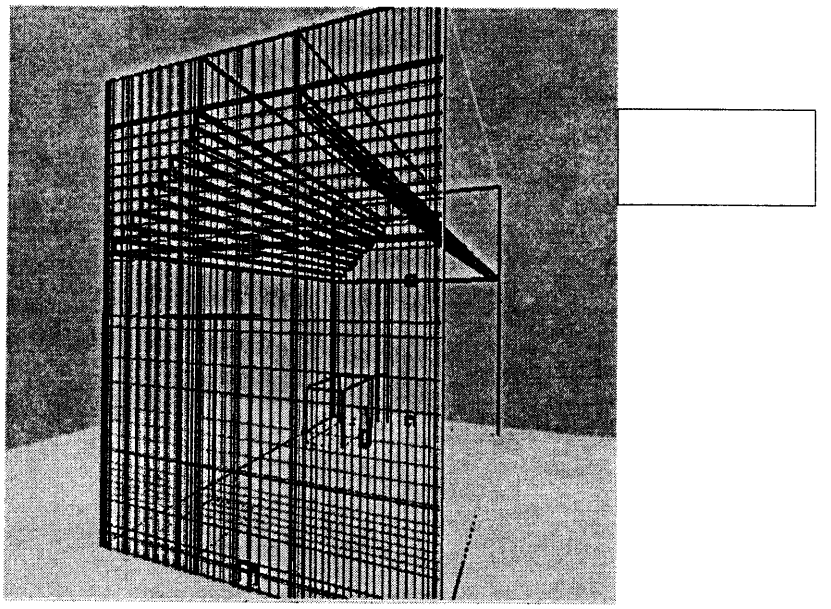


WPI The University of Science and Technology And Life.™

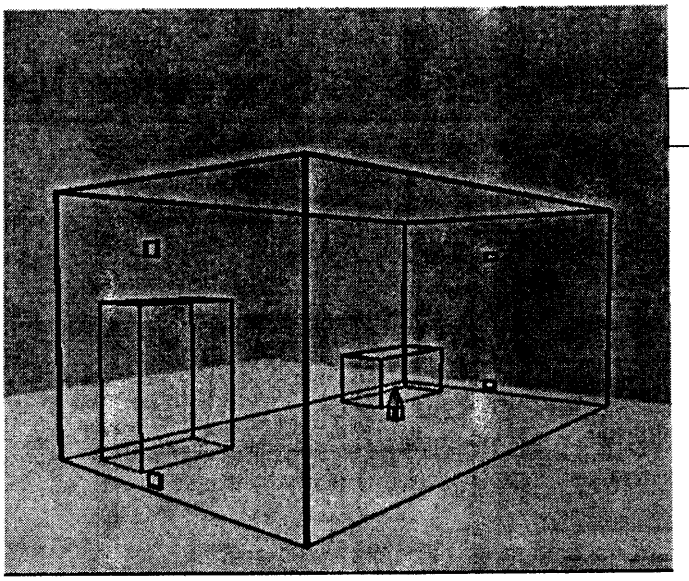
JOSEFINE: Fire Specification



WPI The University of Science and Technology And Life.



WPI The University of Science and Technology And Life.



WPI The University of Science and Technology And Life.™

Major Assumptions

- Material
- Fire
- Geometry
- Radiation
- Turbulence

WPI The University of Science and Technology And Life.™

Running the Simulation

- 400 secs/80 hours
- Data saved every 40 secs
- Reached decay phase

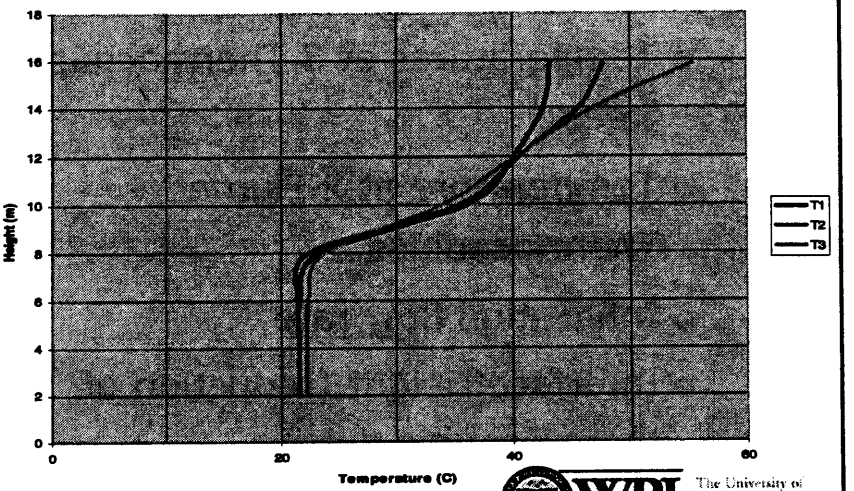
Part 1 –Expected Model Output

- Temperatures at 3 Thermocouple trees
- Temperature at 2 Plume Thermocouples
- Infiltration flow rate
- Interface Height (reduction of thermocouple data)

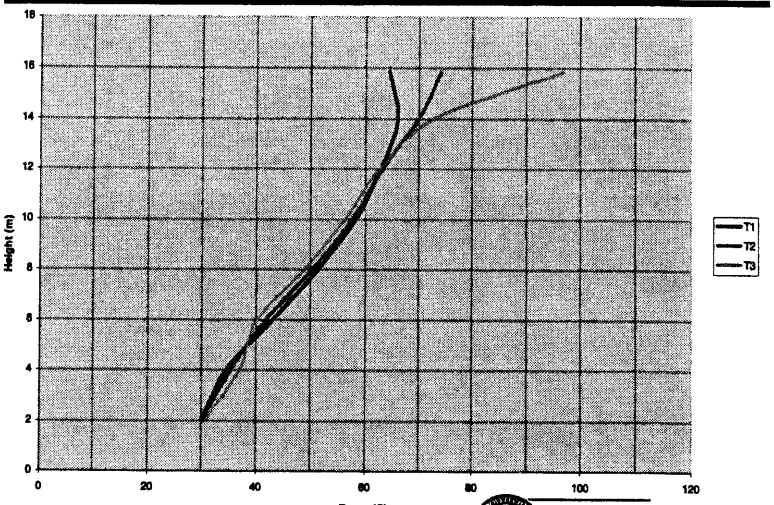
Part 1 –Expected Model Output

- Upper Layer Temperature
- Total Heat Release Rate (within whole hall)

Height v. Temperature @ 120 s

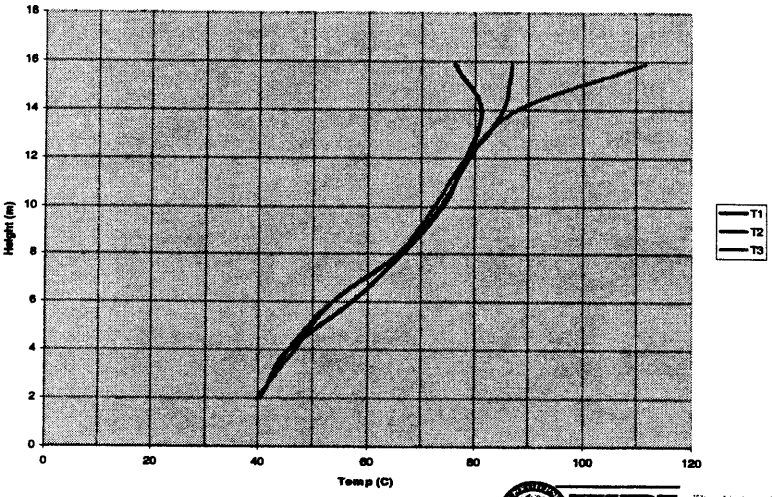


Height v. Temperature @ 240 s



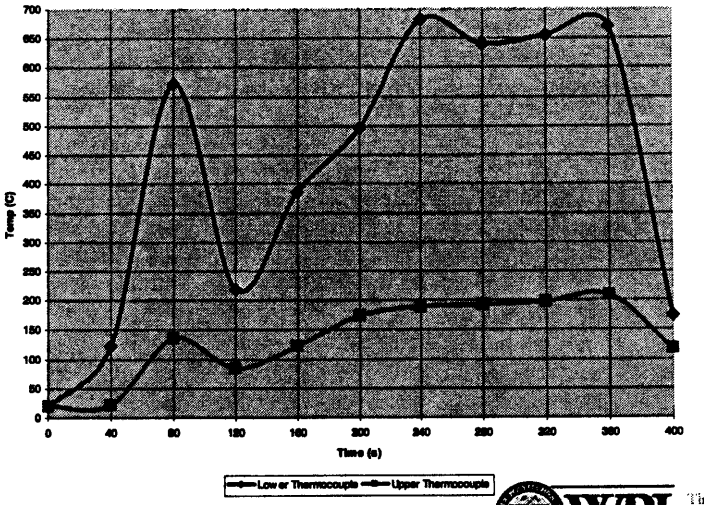
WPI The University of Science and Technology And Life.

Height v. Temperature @ 360 s



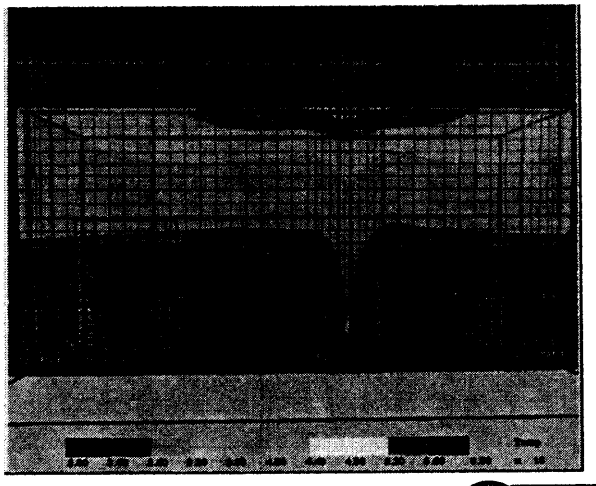
WPI The University of Science and Technology And Life.

Time v. Temp Above Fire



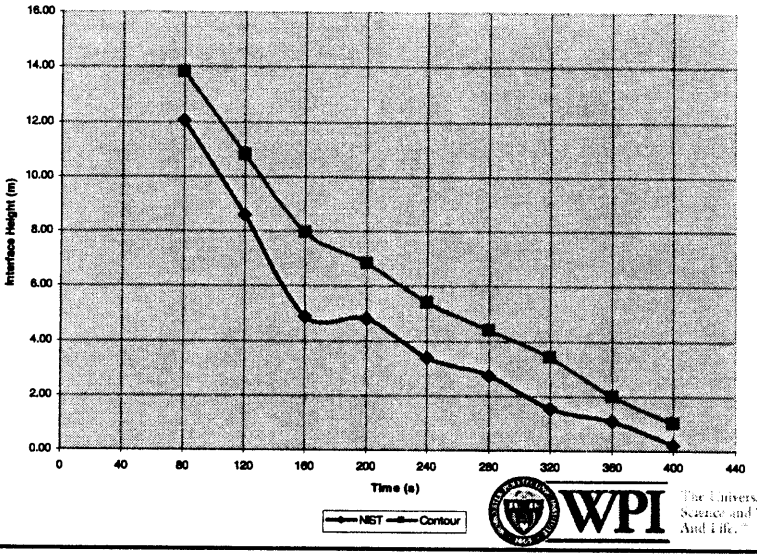
WPI The University of Science and Technology And Life.™

Sample Profile



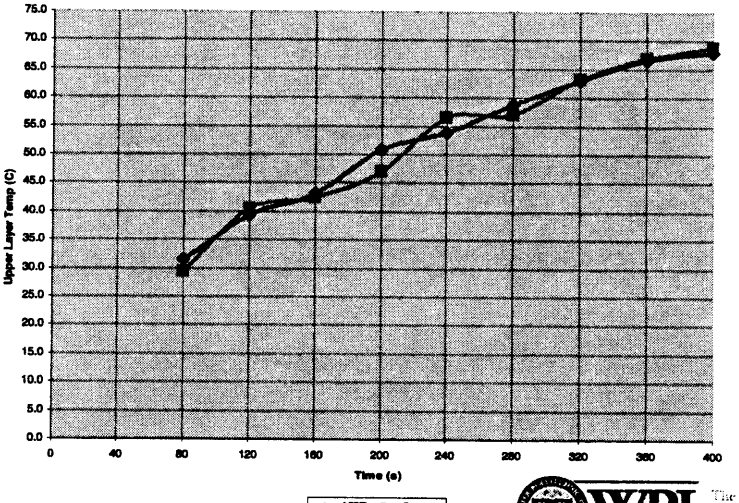
WPI The University of Science and Technology And Life.™

Interface Height v. Time



WPI The University of Science and Technology And Life.

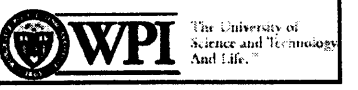
Upper Layer Temp v. Time



WPI The University of Science and Technology And Life.

Conclusion (JASMINE) – According to the Students

- Results appear reasonable (assumptions)
- Fire Modeling can be dangerous



CFAST

- Geometry
- The Fire
- Interpretation of results

CFAST - Geometry

- Conserving the volume of the sloped ceiling,
- Conserving the surface area of the sloped ceiling.
- No significant difference in results:
  - Use rectangular parallelogram with 15.8 m ceiling height (vs actual peak height of 19 m)

Three Cases

- Case 1 uses a pool fire of radius 1.17 meters, assumes the doors are closed, assumes no mechanical exhaust, and uses natural room leakage in the form of four small vents.

Three Cases

- Case 2 assumes a pool fire of radius 1.6 meters, doors closed, no mechanical exhaust, and natural leakage.
- Case 3 assumes a pool fire of radius 1.6 meters, doors open (0.8 m x 4 m), mechanical exhaust on, and no natural leakage.

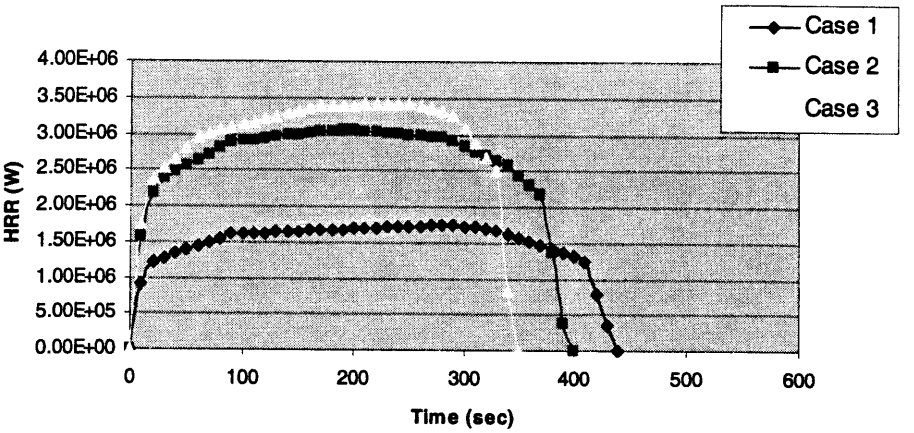
WPI The University of Science and Technology And Life.™

Problem

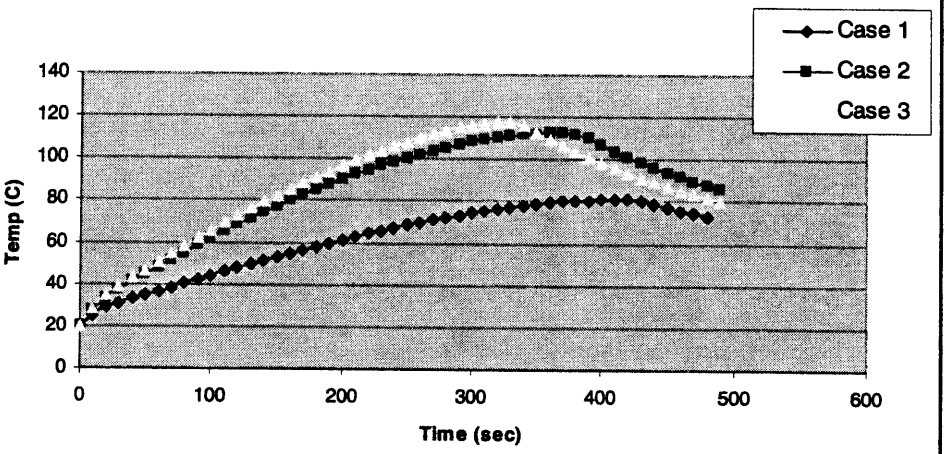
- Couldn't model mechanical exhaust...used natural exhaust

WPI The University of Science and Technology And Life.™

HRR for Each Case



Upper Layer Temperature



CFAST - Summary

- Results only as good as zone model approximation
- Thermocouple predictions limited to layer temperatures

FDS Results

- Similar issues to JASMINE

Overall

- All models created problems for users
- Users highly frustrated with software
- CFAST easiest to use, and therefore sensitivity studies conducted

Acknowledgments - Students

- Jason Cardinal
- Garrett Kaye
- Scott Kelly
- Matthew Klaus
- Jonathan Rich
- Jim Shannon
- Lars Sorthe
- Toby White
- Nick Williams